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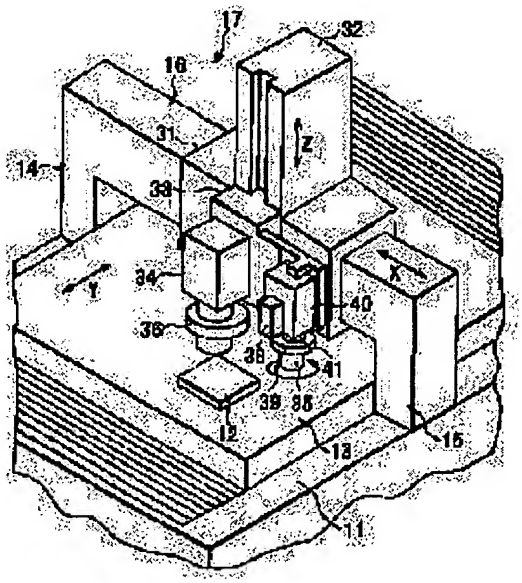
(54) NONCONTACT THREE-DIMENSIONAL MEASURING EQUIPMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To three-dimensionally measure a work with high precision at a high speed.

SOLUTION: Two kinds of measuring means, i.e., a CCD camera 34 used in image measuring equipment, and a laser probe 35 which measures displacement in a noncontact manner by using a laser beam are arranged together, and one imaging unit 17 is constituted. The imaging unit 17 is driven in XYZ directions on the basis of the respective measured values. A work 12 is imaged in a comparatively large range by using the CCD camera 34, and the shape is measured. Fine displacement of the work where judgement of focusing is difficult is measured with the laser probe 35. By using two-dimensional information obtained by the CCD camera 34, a measuring orbit can be easily set. The laser probe 35 measures displacement amount of the work 12 along the set measuring orbit.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The non-contact three-dimensions measuring device characterized by providing the following. The image pck-up unit equipped with the detectable non-contact displacement gage by making into the amount of displacement distance with the predetermined point of measurement on an image pck-up means to picturize a work and to output the 2-dimensional image information for picture measurement, and the aforementioned work The image pck-up unit drive which drives this image pck-up unit in the arbitrary positions in measurement three-dimensions space A position detection means to output the position in the measurement three-dimensions space of the aforementioned image pck-up unit as a three-dimensions coordinate value Control means which the aforementioned image pck-up unit drive is controlled that the point of measurement on the aforementioned work should be moved in accordance with a predetermined measurement orbit so that the amount of displacement which the aforementioned non-contact displacement gage outputs always maintains zero or a predetermined value, a work imitates by incorporating the three-dimensions coordinate value from the aforementioned position detection means, and perform measurement
[Claim 2] The non-contact three-dimensions measuring device characterized by providing the following. The image pck-up unit equipped with the detectable non-contact displacement gage by making into the amount of displacement distance with the predetermined point of measurement on an image pck-up means to picturize a work and to output the 2-dimensional image information for picture measurement, and the aforementioned work The image pck-up unit drive which drives this image pck-up unit in the arbitrary positions in measurement three-dimensions space A position detection means to output the position in the measurement three-dimensions space of the aforementioned image pck-up unit as a three-dimensions coordinate value Control means which the aforementioned image pck-up unit drive is controlled that the point of measurement on the aforementioned work should be moved in accordance with a predetermined measurement orbit, fixing the shaft of the displacement direction which the aforementioned non-contact displacement gage detects, and a work imitates by incorporating the three-dimensions coordinate value from the amount of displacement which the aforementioned non-contact displacement gage detected, and the aforementioned position detection means, and perform measurement
[Claim 3] The aforementioned control means are non-contact three-dimensions measuring devices according to claim 1 or 2 characterized by being what a work imitates in accordance with the measurement orbit specified beforehand, and performs measurement.
[Claim 4] The aforementioned measurement orbit by which specification is carried out is a non-contact three-dimensions measuring device according to claim 3 characterized by being a rectangle.
[Claim 5] The aforementioned measurement orbit by which specification is carried out is a non-contact three-dimensions measuring device according to claim 3 characterized by being a screw type.
[Claim 6] The aforementioned non-contact displacement gage is the non-contact three-dimensions measuring device of the claim 1-5 characterized by being the laser displacement gage which detects the amount of displacement given in any 1 term by irradiating a laser beam spot on a work and receiving the reflected light.
[Claim 7] The aforementioned non-contact displacement gage is the non-contact three-dimensions measuring device of any 1 term of the claims 1-6 characterized by being the displacement gage of the focus method which outputs on a work the movement magnitude of the aforementioned optical system with which a light beam is irradiated through optical system, and the amount of gaps of the focus position and point of measurement becomes zero as an amount of displacement.

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] the distance of the non-contact picture measurement function which measures the profile configuration of the measuring object-ed etc. from the picture which this invention picturized the work with image pck-up meanses, such as a CCD camera, and was acquired, and the measuring plane of a work -- a variation rate -- non-contact [which makes an amount and it detects to non-contact] -- a variation rate -- it is related with the non-contact three-dimensions measuring device equipped with the detection function
[0002]
[Description of the Prior Art] Conventionally, the picture measuring device is used for measurement of the profile configuration of precision parts etc. A picture measuring device picturizes the work which should be measured with arbitrary dilation ratios using a CCD camera, detects an edge from the acquired 2-dimensional picture, and calculates the coordinate value of a required part using various measurement tools. In performing three-dimensions measurement which also includes the height direction of a work by this picture measuring device, a focus judging is performed from the contrast of the picture of a measuring plane, and let this focus position be the position of the height direction.
[0003]
[Problem(s) to be Solved by the Invention] Mounting parts of the fine structure like an LSI package become the big factor as which the quality of conformance of a package determines the yield. For this reason, equipment which can measure each part of a package with high precision is desired. In the conventional picture measuring device, since it is made to measure the position of the height direction (Z shaft orientations) by focus judging, there is a problem that the picture of a comparatively big screen is required to raise the precision of a focus judging, consequently data processing takes time. Moreover, the depth of focus of a CCD camera is usually 1 or several micrometers, although based also on a lens, and within the limits of this, it has the problem that a measurement error is large in order to always judge a focusing point.
[0004] this invention was made in view of such a point, and aims at offering the non-contact three-dimensions measuring device which can carry out three-dimensions measurement of the work at high speed and with high precision.

[0005]
[Means for Solving the Problem] The image pck-up unit which the 1st non-contact three-dimensions measuring device of this invention made distance with the predetermined point of measurement on an image pck-up means to picturize a work and to output the 2-dimensional image information for picture measurement, and the aforementioned work the amount of displacement, and was equipped with the detectable non-contact displacement gage, The image pck-up unit drive which drives this image pck-up unit in the arbitrary positions in measurement three-dimensions space, A position detection means to output the position in the measurement three-dimensions space of the aforementioned image pck-up unit as a three-dimensions coordinate value, The aforementioned image pck-up unit drive is controlled that the point of measurement on the aforementioned work should be moved in accordance with a predetermined measurement orbit so that the amount of displacement which the aforementioned non-contact displacement gage outputs may always maintain zero or a predetermined value. It is characterized by having the control means which a work imitates and perform measurement by incorporating the three-dimensions coordinate value from the aforementioned position detection means.
[0006] Moreover, the 2nd non-contact three-dimensions measuring device of this invention The image pck-up unit equipped with the detectable non-contact displacement gage by making into the amount of displacement distance with the predetermined point of measurement on an image pck-up means to picturize a work and to output the 2-dimensional image information for picture measurement, and the aforementioned work, The image pck-up unit drive which drives

this image pck-up unit in the arbitrary positions in measurement three-dimensions space, A position detection means to output the position in the measurement three-dimensions space of the aforementioned image pck-up unit as a three-dimensions coordinate value, The aforementioned image pck-up unit drive is controlled that the point of measurement on the aforementioned work should be moved in accordance with a predetermined measurement orbit, fixing the shaft of the displacement direction which the aforementioned non-contact displacement gage detects. It is characterized by having the control means which a work imitates and perform measurement by incorporating the three-dimensions coordinate value from the amount of displacement which the aforementioned non-contact displacement gage detected, and the aforementioned position detection means.

[0007] Two kinds of measurement meanses, i.e., the image pck-up means used by the picture measuring device, and the non-contact displacement gage using the laser beam etc. are put side by side, one image pck-up unit is constituted, and it is made to drive this image pck-up unit with an image pck-up unit drive based on each measured value according to this invention. For this reason, while picturizing a work and carrying out configuration measurement in the comparatively large range with an image pck-up means, it enables a focus judging to measure minute displacement of a difficult work with a non-contact displacement gage. Since the non-contact displacement gage measures the amount of displacement of a work in accordance with the measurement orbit which could set up the measurement orbit easily using the 2-dimensional image information obtained with the image pck-up means, and was set up according to this invention, a highly precise work imitates at high speed, and measurement becomes possible.

[0008] If an image pck-up unit drive is controlled so that it imitates and the amount of displacement of a non-contact displacement gage always maintains zero or a predetermined value as the method of measurement, and the three-dimensions coordinate value from a position detection means is incorporated, the displacement measurement of the latus range which is not restricted to the measuring range of a non-contact displacement gage will become possible. moreover -- imitating -- as the method of measurement -- non-contact -- a variation rate -- the variation rate which type detects -- the variation rate which fixed the shaft of a direction and the non-contact displacement gage detected -- if the three-dimensions coordinate value from an amount and a position detection means is incorporated, measurement by the very high accuracy of measurement which a non-contact displacement gage has will be attained

[0009] In addition, although how to set automatically using an orbit, a design data, etc. with which imitated and the measurement orbit in the case of measurement was beforehand decided to be etc. can be considered, it is also possible to specify arbitrary configurations beforehand, for example like a rectangle and a screw type. Furthermore, the laser displacement gage which detects the amount of displacement can be used by irradiating a laser beam spot, for example on a work, and receiving the reflected light as a non-contact displacement gage. Moreover, the displacement gage of the focus method which outputs the movement magnitude of the aforementioned optical system with which a light beam is irradiated through optical system, and the amount of gaps of the focus position and point of measurement becomes zero as an amount of displacement for example, on a work can be used for a non-contact displacement gage.

[0010]

[Embodiments of the Invention] Hereafter, the gestalt of desirable implementation of this invention is explained with reference to a drawing. Drawing 1 is the perspective diagram showing the whole non-contact three-dimensions measuring device composition concerning one example of this invention. This equipment is constituted by the three dimensional measurer 1 equipped with the non-contact picture measurement function and the non-contact displacement measurement function, and the computer system 2 which performs required data processing while carrying out drive control of this three dimensional measurer 1.

[0011] The three dimensional measurer 1 is constituted as follows. That is, it is equipped with the measurement table 13 which lays the work 12 which is the measuring object-ed on the stand 11, and this measurement table 13 is driven to Y shaft orientations with the Y-axis drive which is not illustrated. The support arms 14 and 15 prolonged up are being fixed to the edges-on-both-sides center section of the stand 11, and the X-axis guide 16 is being fixed so that both the upper-limits section of these support arms 14 and 15 may be connected. The image pck-up unit 17 is supported by this X-axis guide 16. The image pck-up unit 17 is driven along with the X-axis guide 16 with the X-axis drive which is not illustrated. A computer system 2 is equipped with the computer 21 which manages measurement information processing and various control, the keyboard 22, the joy stick box 23 and mouse 24 which input various directions information, CRT display 25 which displays a measurement screen, a directions screen, and a measurement result, and the printer 26 which prints out a measurement result, and is constituted.

[0012] The interior of the image pck-up unit 17 is constituted as shown in drawing 2 . That is, along with the X-axis guide 16, a slider 31 is formed possible [movement], and the Z-axis guide 32 is being fixed to the slider 31 by one. A support plate 33 is formed in this Z-axis guide 32 free [sliding of Z shaft orientations], and CCD camera 34 which is an image pck-up means for picture measurement, and the laser probe 35 which is a non-contact displacement gage are put side by side to it at this support plate 33. This maintains physical relationship with fixed CCD camera 34 and laser probe

35, and it can move now to 3 shaft orientations of X, Y, and Z simultaneously. The lighting system 36 for illuminating the image pck-up range is added to CCD camera 34. In order to check the measuring point by the laser beam of the laser probe 35, CCD camera 38 which picturizes the circumference of a measuring point, and the lighting system 39 for illuminating the measuring point of the laser probe 35 are formed in the near position of the laser probe 35. The laser probe 35 is supported by the vertical-movement mechanism 40 for evacuating the laser probe 35 in the case of movement of the image pck-up unit 17, and the rolling mechanism 41 for fitting the directivity of a laser beam in the optimal direction.

[0013] Drawing 3 is drawing showing the detail of the laser probe 35. After the light emitted from semiconductor laser 51 minds a beam splitter 52 and 1/4 wavelength plate 53, with a collimate lens 54, it is made into an parallel beam of light, and forms an optical spot in the test section of a work 12 through mirrors 55 and 56 and an objective lens 57. The reverse path of mirrors 56 and 55, a collimate lens 54, and 1/4 wavelength plate 53 is followed, it is reflected by the beam splitter 52, and the light reflected from the test section of a work 12 is halved up and down by the edge mirror 58. The light divided up and down is detected by 2 division photo detectors 59 and 60 arranged up and down. A detector 61 outputs the signal according to the amount of gaps from the focal position of an objective lens 57 to the measuring plane 62 of a work 12 based on the output signal from 2 division photo detectors 59 and 60. The servo circuit 63 outputs the driving signal for the drive of an objective lens 57 to a drive 64 based on the detection output of a detector 61. Vertical movement of an objective lens 57 moves the movable member 67 of a displacement pickup 66 to a holddown member 68. This movement magnitude is outputted as an amount of displacement.

[0014] The block diagram of the whole equipment in which the composition of a three dimensional measurer 1 and a computer system 2 was shown still in detail is shown in drawing 4 . In a three dimensional measurer 1, after the picture signal which picturized the work 12 and was acquired by CCD camera 34 for picture measurement and CCD camera 35 for the measuring-point check of the laser probe 35 is changed into multiple-value image data by A/D converters 71 and 72, respectively, either is chosen by the selection circuitry 73 and it is supplied to a computer 21. Based on control of a computer 21, a lighting light required for the image pck-up of CCD cameras 34 and 38 is given, when the lighting control sections 74 and 75 control lighting systems 36 and 39, respectively. The signal of the amount of displacement obtained from the laser probe 35 is supplied to a computer 21 through A/D converter 76. And the image pck-up unit 17 containing these drives to XYZ shaft orientations by the XYZ shaft mechanical component 77 which operates based on control of a computer 21. The position of the XYZ shaft orientations of the image pck-up unit 17 is detected by the XYZ shaft encoder 78, and is supplied to a computer 21.

[0015] On the other hand, the computer 21 is constituted by CPU81 which makes the center of control, the multiple-value picture memory 82 connected to this CPU81, the program storage section 83, the work memory 84 and interfaces 85 and 86, and the display-control section 87 for displaying the multiple-value image data memorized by the multiple-value picture memory 81 on CRT display 25. CPU81 switches a selection circuitry 73 in picture measurement mode and laser measurement mode. The multiple-value image data for picture measurement or the multiple-value image data for laser measurement chosen by the selection circuitry 73 is stored in the multiple-value picture memory 82. The multiple-value image data stored in the multiple-value picture memory 82 is displayed on CRT display 25 by display-control operation of the display-control section 87. On the other hand, an operator's directions information that it is inputted from a keyboard 22, a joy stick 23, and a mouse 24 is inputted into CPU81 through an interface 85. Moreover, to CPU81, the amount of displacement, XYZ coordinate information from the XYZ shaft encoder 78, etc. which were detected with the laser probe 35 are incorporated. CPU81 performs various kinds of processings, such as data processing of stage movement by the XYZ shaft mechanical component 77, and measured value, based on the program stored in directions of these input and an operator and the program storage section 83. The work memory 84 offers the working area for various processings of CPU81. Measured value is outputted to a printer 26 through an interface 86.

[0016] Next, the measurement processing and data processing of a non-contact three-dimensions measuring device concerning this example constituted in this way are explained. With this equipment, it has picture measurement mode and laser measurement mode. In picture measurement mode, since the same operation as the conventional picture measuring device is made, ** laser measurement mode is explained here.

[0017] Drawing 5 is a flow chart by laser measurement mode which imitates and shows the procedure of measurement. First, proofreading of the picture for picture measurement and the laser probe 35 is performed (S1). That is, the fixture 91 which contains the measurable two straight-lines components L1 and L2 which are not parallel with CCD camera 34 and the laser probe 35 as shown in drawing 6 is laid on the stage 13 of a three dimensional measurer 1. This fixture 91 is easy to be what has arranged the trapezoid pattern 93 of the predetermined width of face h for example, on a substrate 92. By measuring straight lines L1 and L2 within the plane of projection of Z shaft orientations with CCD camera 34 and the laser probe 35, respectively, asking for the equation of these straight lines, respectively, and carrying out data processing of the obtained formula, the offset value between each axis of coordinates of CCD camera 34 and the laser

probe 35 is calculated, and this offset value is used as position calibration data of CCD camera 34 and the laser probe 35.

[0018] If proofreading processing is completed next, picture measurement of the work 12 will be carried out, the position of a work 12 will be checked, and the point of measurement by the laser probe 35 will be moved to a measurement start point (S2). Since the laser probe 35 may interfere with a work 12 in the case of picture measurement, the laser probe 35 is evacuated upwards according to the vertical-movement mechanism 40 during picture measurement. Control is performed by the pneumatic cylinder. Next, if laser measurement mode is chosen (S3), a selection circuitry 73 will change and the screen of CRT display 25 will turn into a screen of CCD camera 38 for laser measurement from CCD camera 34. With this screen, the position (measuring point) of the laser beam spot from the laser probe 36 is checked (S4). Here, the position of the beam spot can also be finely tuned using a joy stick 23 or mouse 24 grade. In addition, since CCD camera 38 is for checking whether the laser beam spot has hit the target position on a work 12 correctly, it does not use the image data for measurement. For this reason, it does not need to be so highly minute as CCD camera 34 for picture measurement. Moreover, only with the light of laser, since only the position of a laser spot looks bright, the surroundings of it become dark and a beautiful picture is not acquired, it switches to the lighting system 39 of exclusive use. Of course, it is also possible to use CCD camera 38 and a lighting system 39 also [lighting system / CCD camera 34 and / 36].

[0019] Next, in order to imitate and to give the path of measurement, a measurement tool is chosen and a required parameter is set up (S5). As a measurement tool, a thing as shown, for example in drawing 7 can be considered.

(a) Measure X of the point of measurement (black dot) of point tool present, Y, and a Z coordinate value.

(b) Give the straight-line tool terminal point position Pe, imitate and measure the straight-line top from the present point of measurement to a terminal point Pe.

(c) Give the width of face W of field tool field reference, height H, and pitches PT1 and PT2, from the present point of measurement, moving reciprocately in a specification pitch, imitate and measure the inside of the appointed field.

(d) Give the circle tool radius R, Pitch PT, and the start angle theta, from the present point of measurement, imitate and measure a concentric circle top.

(e) Give the rectangle tool width of face W and height H, and imitate and measure along with a rectangle.

(f) Give the length L1 and L2 of two segments which intersect perpendicularly with cross tool each other, imitate and measure a cross-joint top.

(g) Give the spiral tool maximum radius R and Pitch radiographic (radius value which increases by one rotation), imitate and measure the shape of a spiral.

(h) Only take a focus by the focal tool current position.

[0020] If a measurement tool is chosen and a required parameter is set up, it will imitate and measurement will be performed (S6). There is some directivity in the displacement detection precision of the laser probe 35. For this reason, when measuring a profile and surface roughness in accordance with an orbit, the laser probe 35 is rotated by the rolling mechanism 41 so that the laser probe 35 may turn to the optimal direction to the direction to which this orbit goes. It is more effective if it measures rotating the laser probe 35 in measuring in accordance with a circular orbit or a spiral orbit.

[0021] The XYZ shaft mechanical component 77 is driven based on the amount of displacement from the laser probe 35, and Z shaft-orientations position of the image pck-up unit 17 is made to go up and down, so that it may imitate and the coordinate value of Z shaft orientations may be obtained in the measuring range of the laser probe 35 on the occasion of measurement exceeding the range of **0.5mm, for example, as shown in drawing 8 . This controls for the focus position of the laser probe 35 to always take the lead in measuring range. In this case, the Z-axis coordinate value obtained with the XYZ shaft encoder 78 serves as the amount of displacement of Z shaft orientations. What is necessary is just to compute the right amount of displacement by amending a Z-axis coordinate value in the amount of displacement of the laser probe 35, in order to perform high-speed measurement for which the position control of Z shaft orientations is not of use. Moreover, when measuring the minute surface roughness within the measuring range of the laser probe 35, as shown in drawing 9 , Z shaft-orientations position of the laser probe 35 can be fixed, and it can respond only by drive control of the objective lens 57 in the laser probe 35, and while still more nearly high-speed processing is possible, measurement of a high resolution (for example, 0.01 micrometers) is attained in [resolution / by Z-axis drive / (for example 0.1 micrometers)] this case. In accordance with such a measurement orbit that imitated and was specified by measurement, the coordinate value of Z shaft orientations is calculated as sequence-of-points data with X and a Y-axis coordinate value at the predetermined intervals, and this is stored in the work memory 84. If sequence-of-points data are called for, analysis processing of sequence-of-points data will be performed (S7).

[0022] Next, analysis processing of sequence-of-points data is explained. The profile configuration measurement data obtained by this non-contact three-dimensions measuring device to a conventional profile configuration measurement

machine and a conventional surface roughness measurement machine being 2-dimensional data is three-dimensions data. And in order [in alignment with the 2-dimensional specification orbit] to measure by imitating, data processing is complicated more. Then, in order to simplify data processing, analysis processing of the following sequence-of-points data is performed. Based on the flow chart of drawing 10 , and the wave form chart of drawing 11 , analysis processing of this sequence-of-points data is explained.

[0023] First, since work 12 the very thing may lean, an average side (in the case of a straight line, it is an average line) is searched for from sequence-of-points data, and trend amendment of data is performed to this field (S11). The sequence-of-points data which are shown in this drawing (b) and by which trend amendment was carried out are obtained from leaning sequence-of-points data as this shows to drawing 11 (a). Next, the sequence-of-points data of three dimensions are changed into 2-dimensional sequence-of-points data, using the 1st shaft orientations and the direction of a normal of the above-mentioned average side as the 2nd shaft orientations for travelling direction in accordance with a measurement orbit (S12). Thereby, data like drawing 11 (c) are obtained. Since this sequence-of-points data is obtained by the scan accompanied by the acceleration and deceleration in alignment with the measurement orbit, it is not a constant pitch. Since Gaussian (Gaussian) filtering usually used with FFT (fast Fourier transform), the configuration measurement machine, etc. cannot be performed unless it is a constant pitch, constant pitch-ized processing is performed here (S13 : drawing 11 (d)). Next, Gaussian filter processing is performed (S14 : drawing 11 (e)). And the pitch-ized constant data are returned to the position (position of an unfixed pitch) of a basis (S15 : drawing 11 (f)). Next, 2-dimensional -> three-dimensions conversion for returning the 2-dimensional data changed at Step S12 to up to the measurement orbital position (XY position) of a basis is performed (S16 : drawing 11 (g).). Finally amendment of the inclination processed by data trend amendment of Step S11 is returned, and data are changed in the direction to which the work 12 originally leans (S17 : drawing 11 (h)).

[0024] Three-dimensions sequence-of-points data are easily filterable with the above processing. Moreover, since the data after processing of Step S14 are 2-dimensional data by which filtering was carried out in the constant pitch, various analysis processings which are performed with a usual profile configuration measurement machine, a usual surface roughness measurement machine, etc. are attained.

[0025]

[Effect of the Invention] The image pck-up means which was expressed above and which is used with two kinds of measurement meanses, i.e., a picture measuring device, according to [like] this invention, Since the non-contact displacement gage using the laser beam etc. is put side by side, one image pck-up unit is constituted and it is made to drive this image pck-up unit with an image pck-up unit drive based on each measured value, While picturizing a work and carrying out configuration measurement in the comparatively large range with an image pck-up means, it enables a focus judging to measure minute displacement of a difficult work with a non-contact displacement gage. For this reason, since the non-contact displacement gage measures the amount of displacement of a work in accordance with the measurement orbit which could set up the measurement orbit easily using the 2-dimensional image information obtained with the image pck-up means, and was set up according to this invention, a highly precise work imitates at high speed, and the effect that measurement becomes possible is done so.

[Translation done.]

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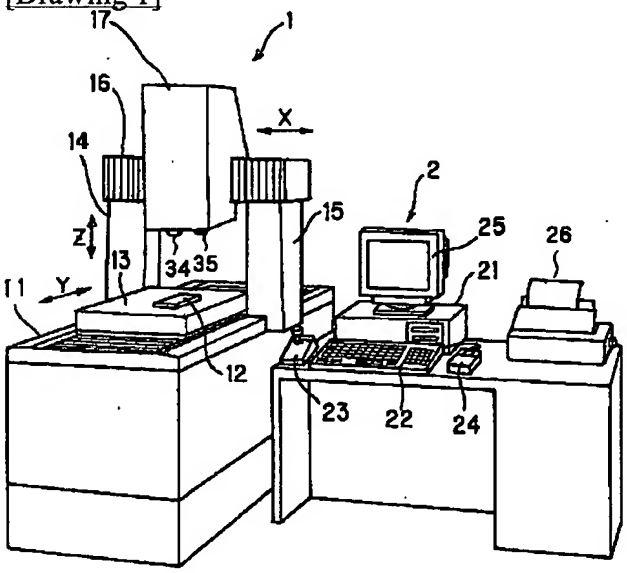
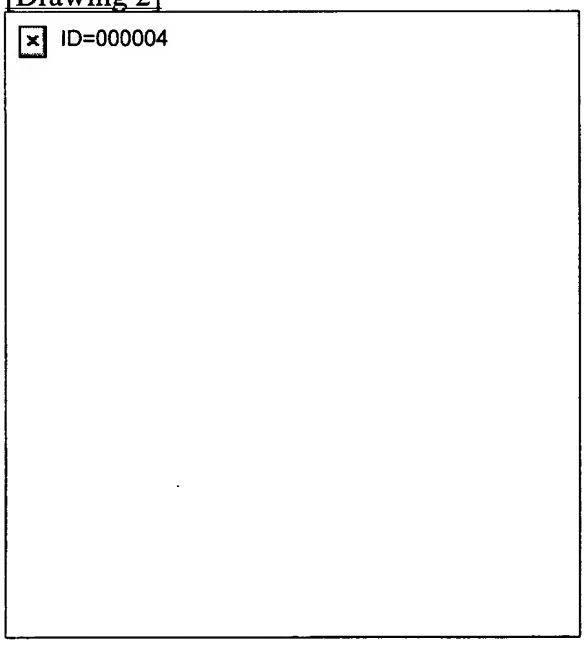
DRAWINGS

[Drawing 1]



[Drawing 2]



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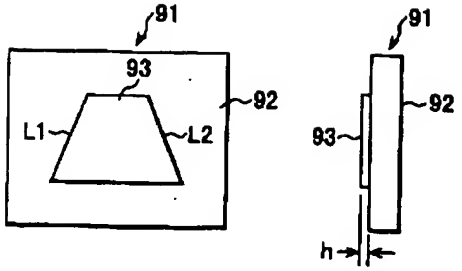
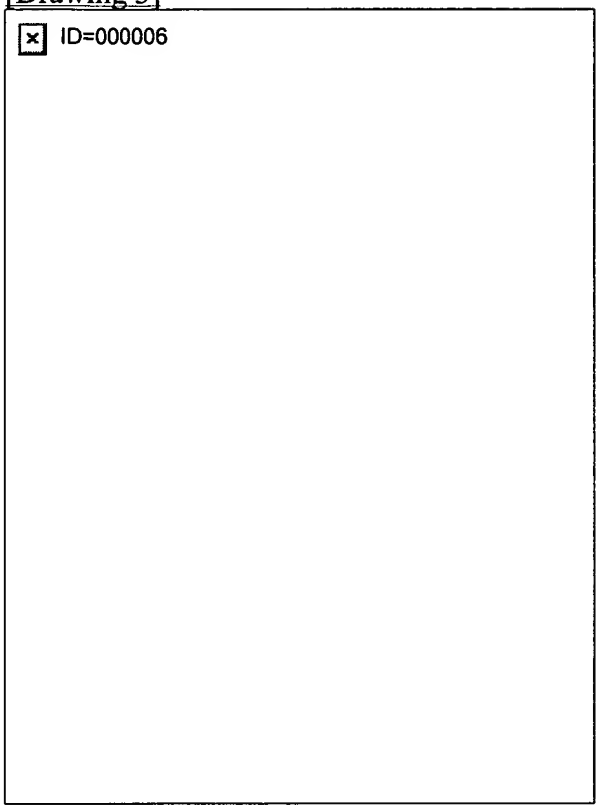
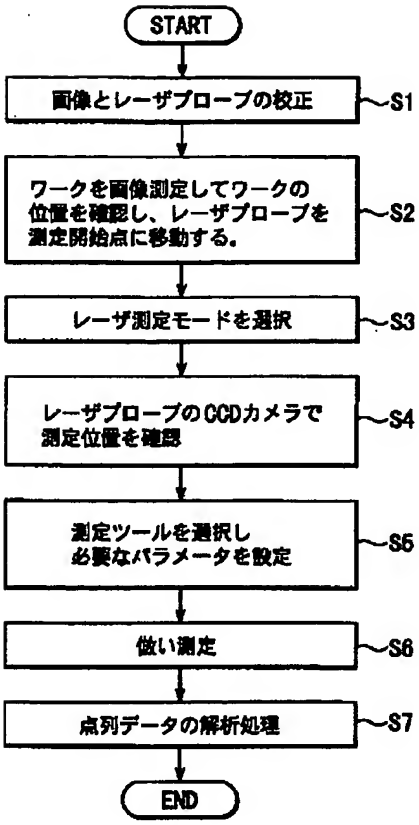


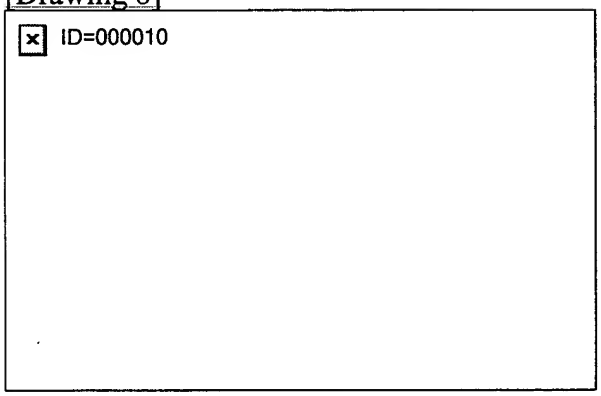
[Drawing 3]



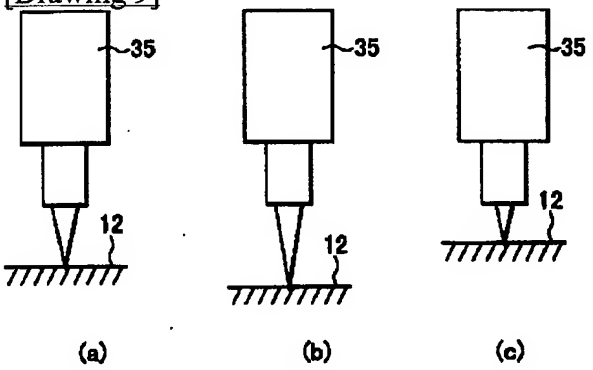
[Drawing 5]



[Drawing 8]



[Drawing 9]



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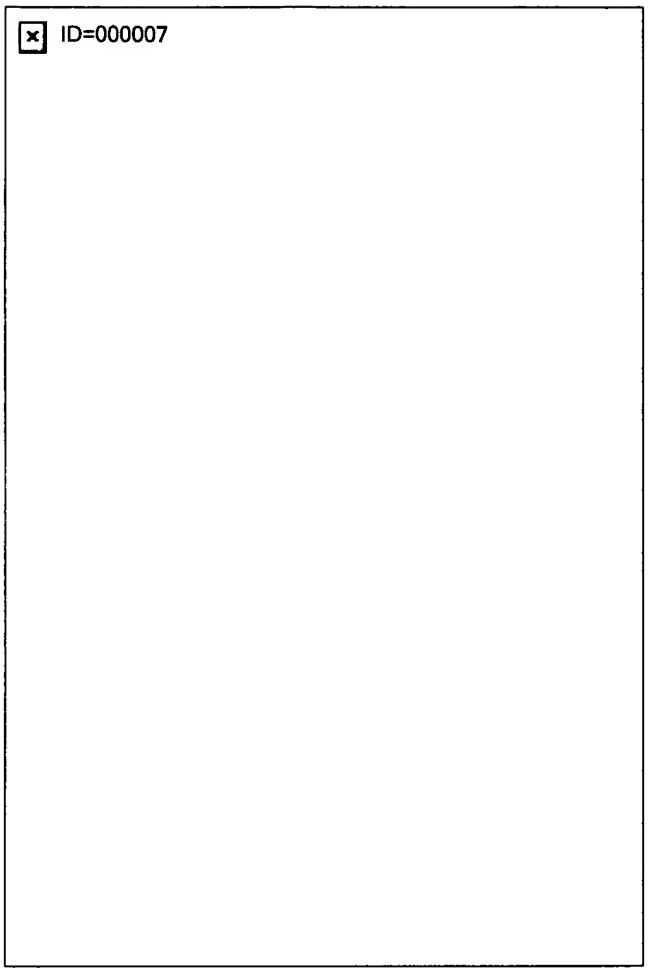
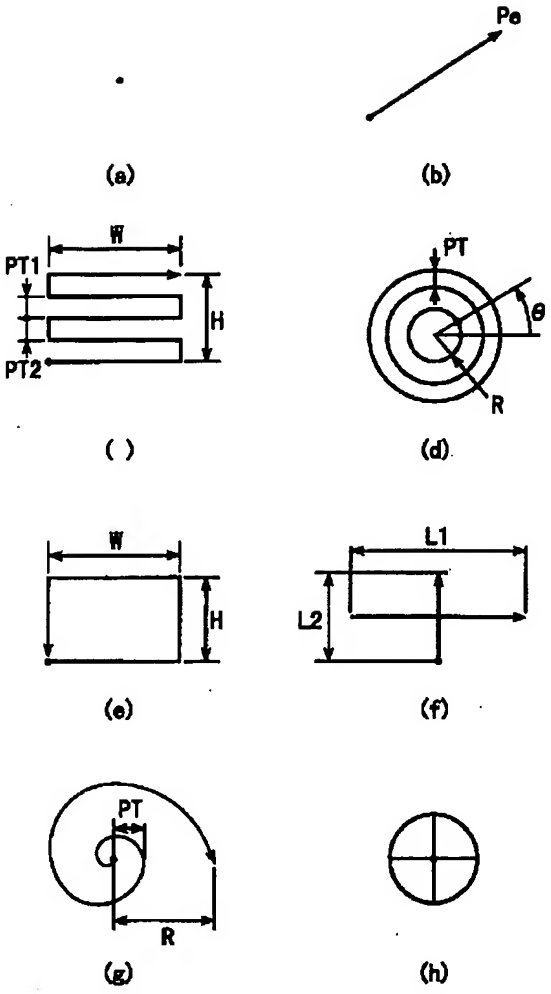
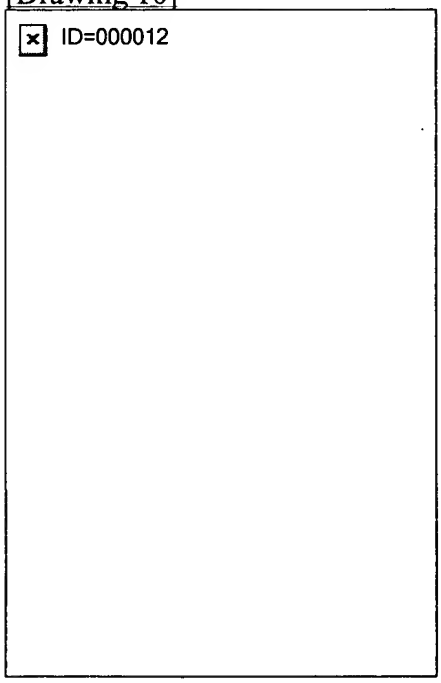


[Drawing 7]

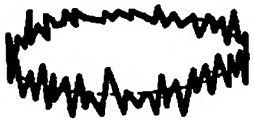


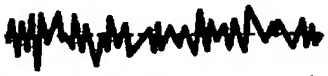
[Drawing 10]



[Drawing 11]

(a) 

(b) 

( ) 

(d) 

(e) 

(f) 

(g) 

(h) 

[Translation done.]